Dealing with subsidence in deltas

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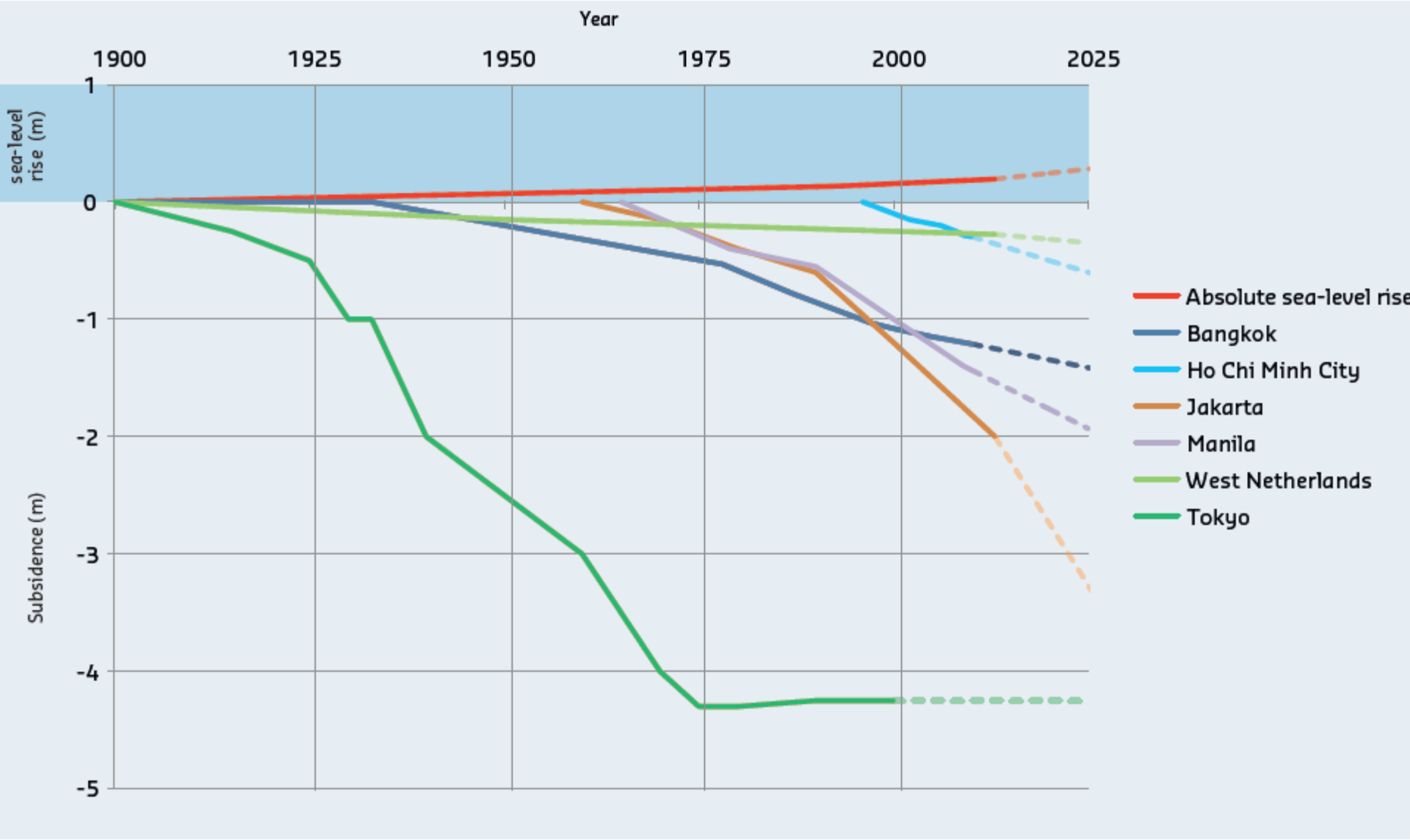
Land subsidence vs absolute sea-level



Strategies: Adaptation vs Mitigation

Terminology derived from climate change research community

- **Adaptation** = subsidence continuous, living with the consequences
- **Mitigation** = actively reducing or stopping subsidence

Mitigation measures for human-induced land subsidence

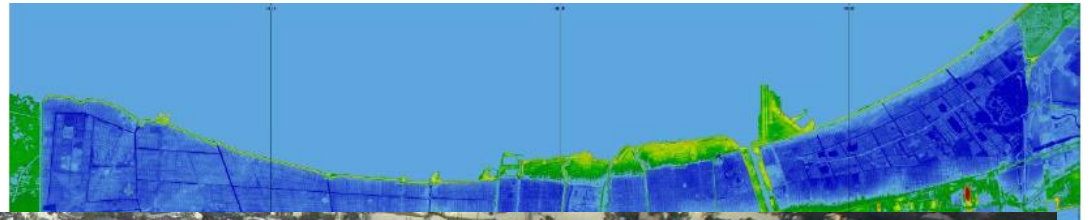
- ✓ Diminish pumping, aquifer storage recovery

Adaptation for natural and remaining human-induced land subsidence

- ✓ Reintroducing sediment in delta's, building higher levees
- ✓ Adapted spatial planning

1. Adaptation-focused

- The New Orleans story



- This is the traditional strategy (in the Netherlands followed for ~1000 yrs)
- It is the base-line strategy
- This is the easy strategy on the shorter term
- If you have no strategy, this is your strategy (but you may not be aware of it)

Adaptation measures

Actors involved

After Katrina (2005)

- Federal:
  - FEMA (Federal Emergency Management Agency)
  - USACE (United States Army Corps of Engineers)
- Outside the Federal levee system:
  - Parish levee system
  - the individual

Economic aspects

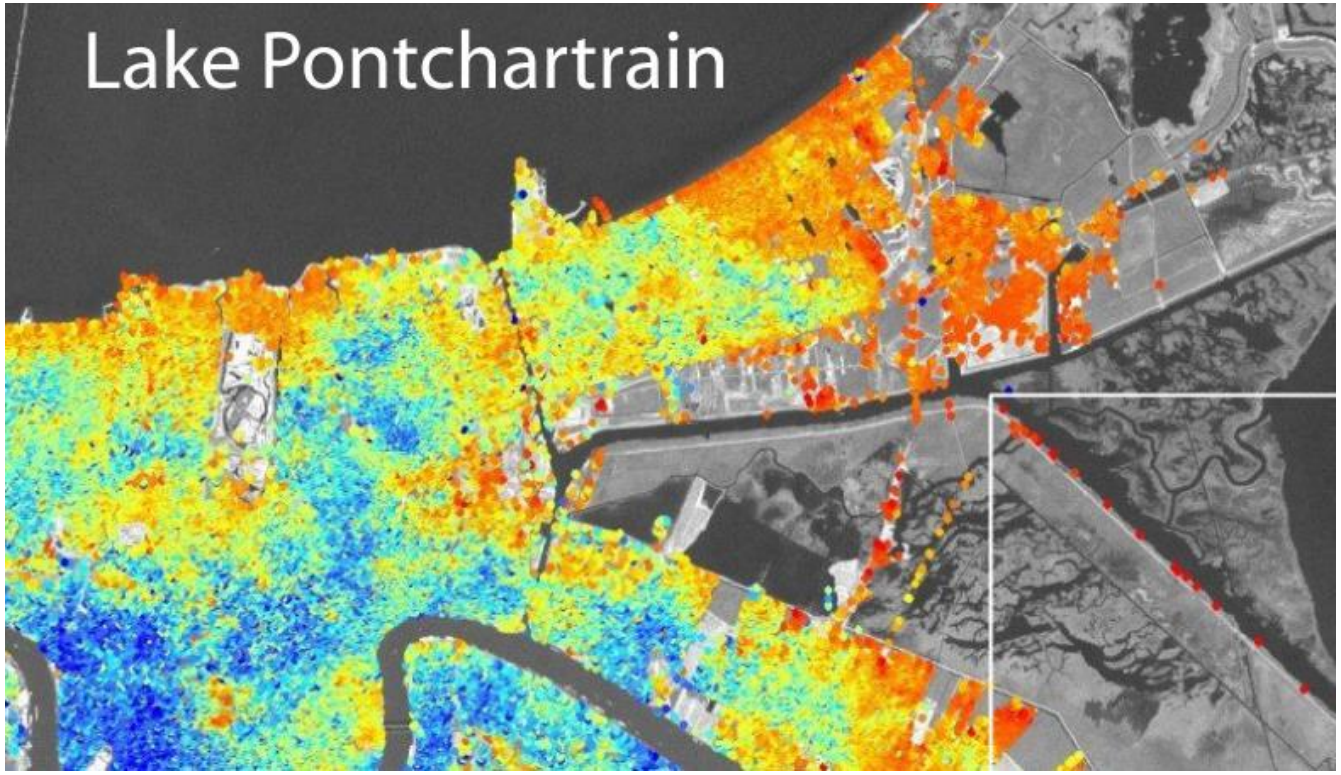
- “This allowed billions of gallons of water (…) to surge in to New Orleans (…), claiming nearly 2,000 lives, leaving hundreds of thousands homeless and causing more than $100bn in damage to property and infrastructure.”
- “(…) the nation's commitment to the people of New Orleans by spending $14.6bn on what is the best risk reduction system certainly in the United States, if not indeed the world (…)“
- These costs are not solely subsidence adaptation related, but are also the result of the hurricane climate in New Orleans, and the position at the Mississippi River.

…and subsidence continues

Large sections of New Orleans' levee system sinking

By Tom Hall
1 June 2015

Large sections of the $14.5 billion levee system constructed around the New Orleans area after Hurricane Katrina in 2005 are sinking and will have to be raised by 2025 in order to keep the areas inside the levees qualified for federal flood insurance, according to a report published May 20 by *The Lens*, a local investigative journalism outfit.



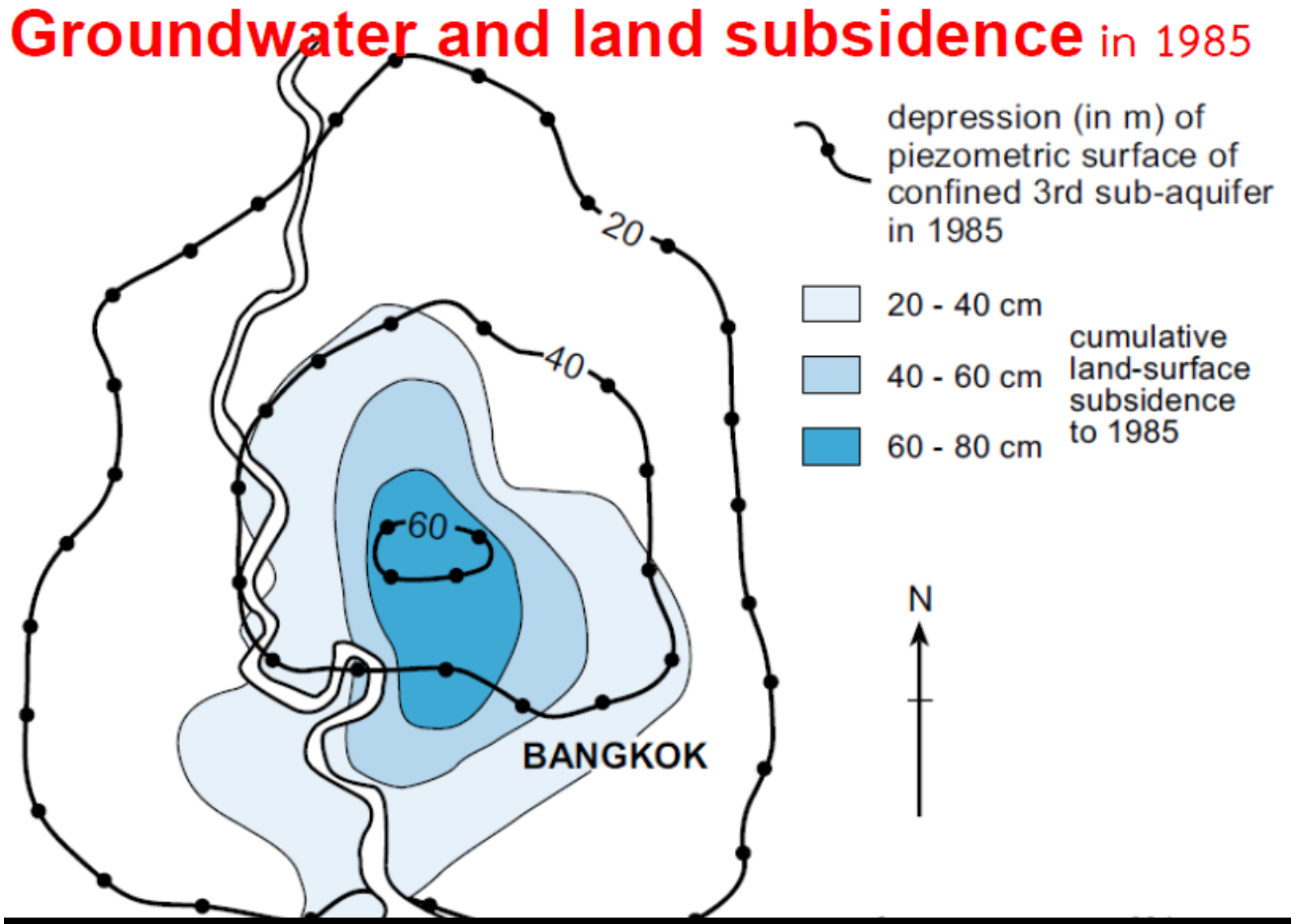
Detail of InSAR image New Orleans

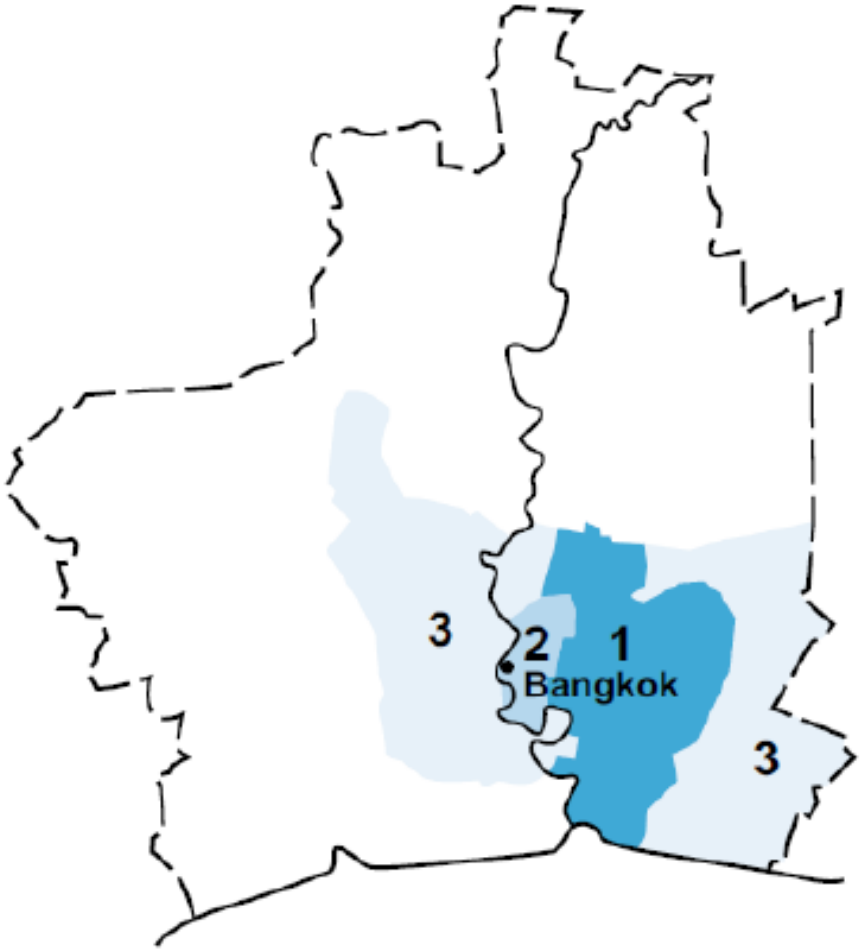
2a. Mitigation/adaptation – by financial arrangements

Oranuj Lorphensri, Ph.D.
Director, Bureau of Groundwater Control
Department of Groundwater Resources

Example case:

- Bangkok, Thailand

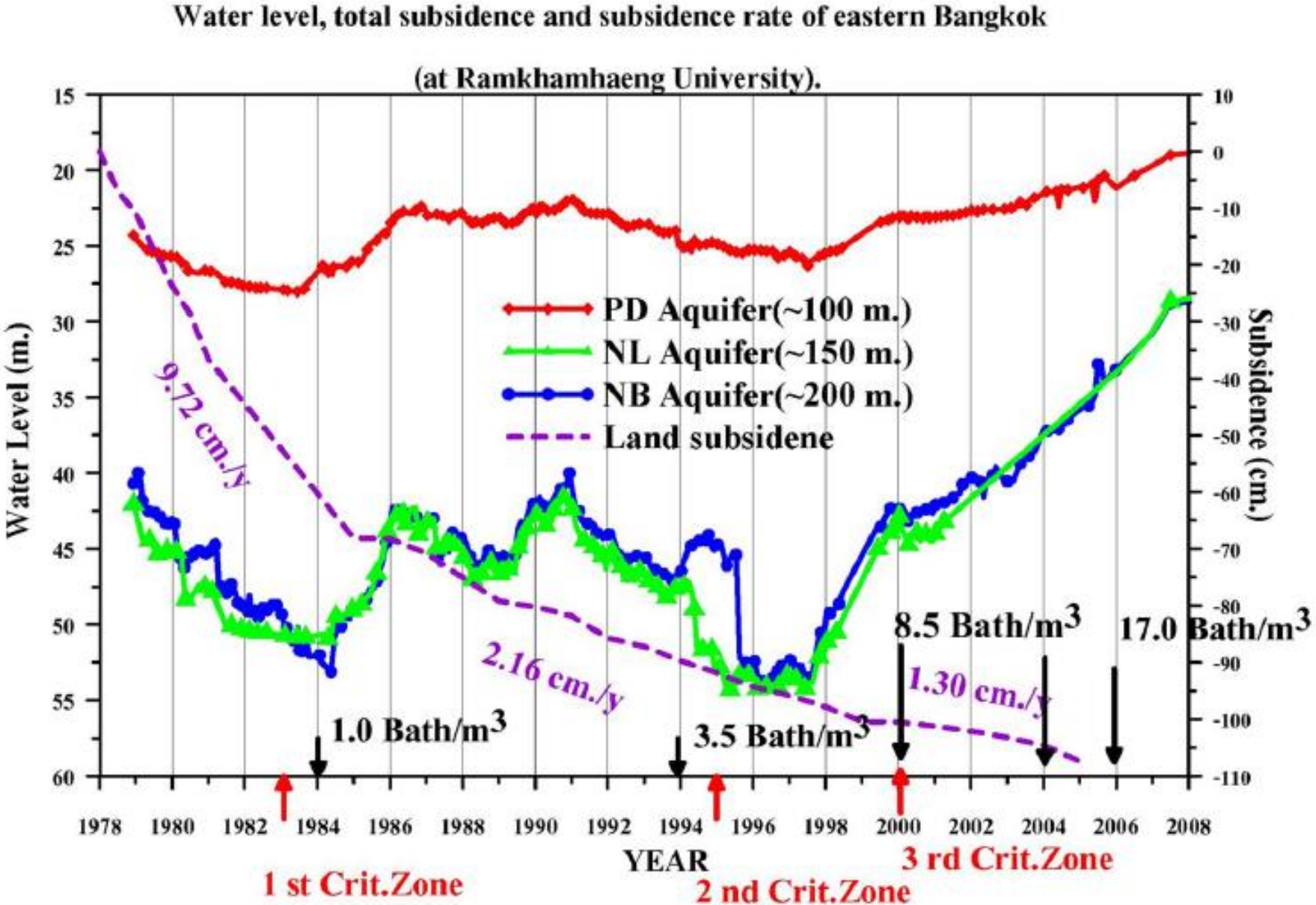




Measures included

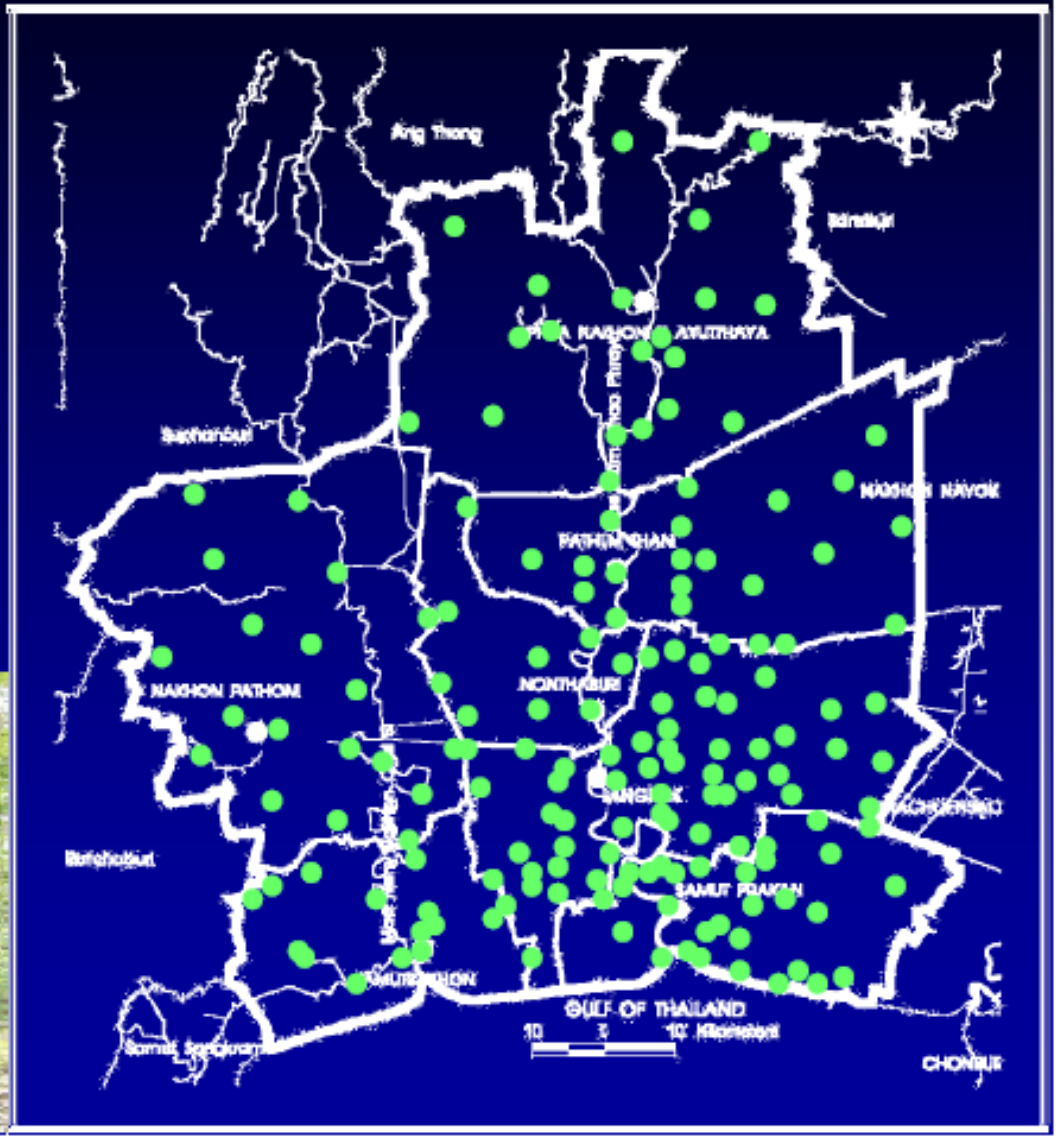
- **'critical area'** where water well drilling would be banned
- Powers to seal water wells in area with main water-supply coverage
- Licensing and charging for groundwater abstraction according to metered or estimated

Results of taxation measures

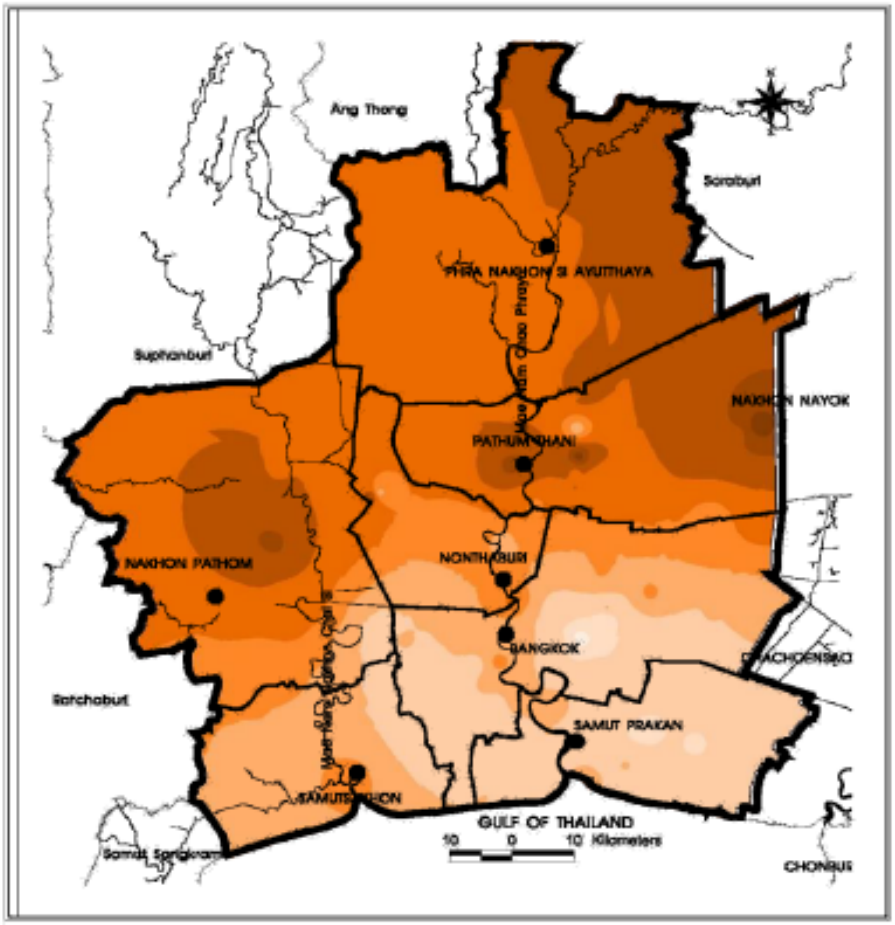


Groundwater monitoring stations

- 1978 First Established
  60 observation wells
- In 1985,
  258 observation wells
- At present,
  521 observation wells
  (163 stations)

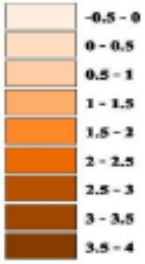


Results of measures in Bangkok



- Land subsidence was over 10 cm/yr in the eastern suburbs, and 5 to 10 cm/yr in central Bangkok.
- After control measures for the groundwater uses in1983, it showed evident of decreasing rate of land subsidence and continuous recover of water.
- Now , overall area subsidence rate is 1 cm/yr. The higher rate of 2 cm/year still can be found at Samut Prakan the eastern province and Samut Sakhon the western

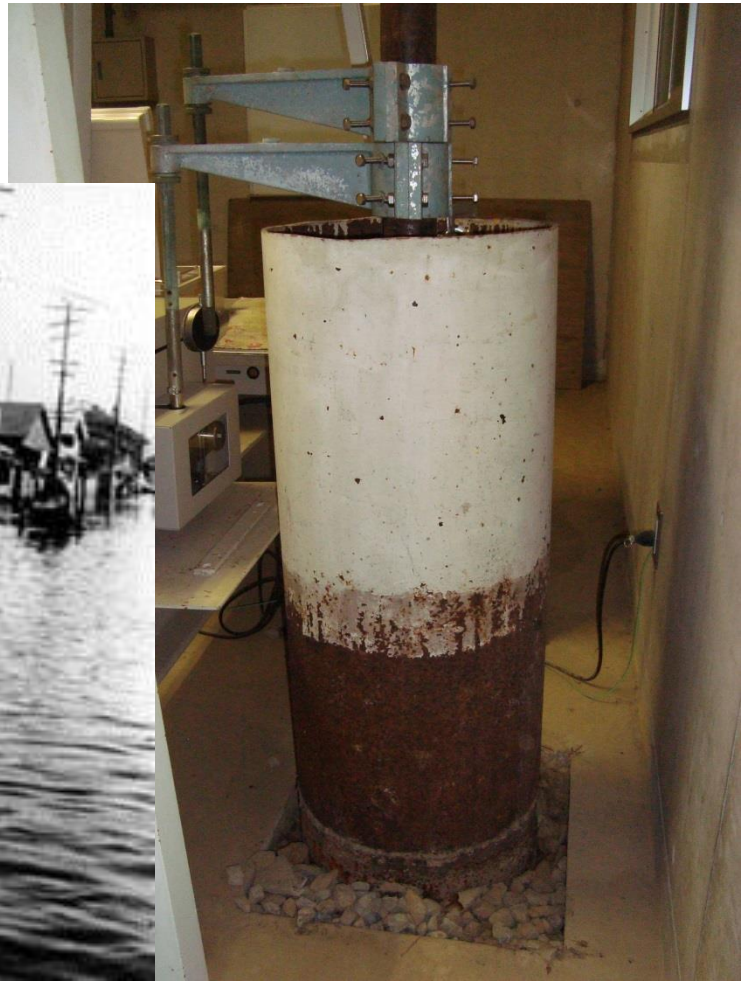
Elevation (meter)



Case 3. Mitigation-focused Groundwater extraction stopped

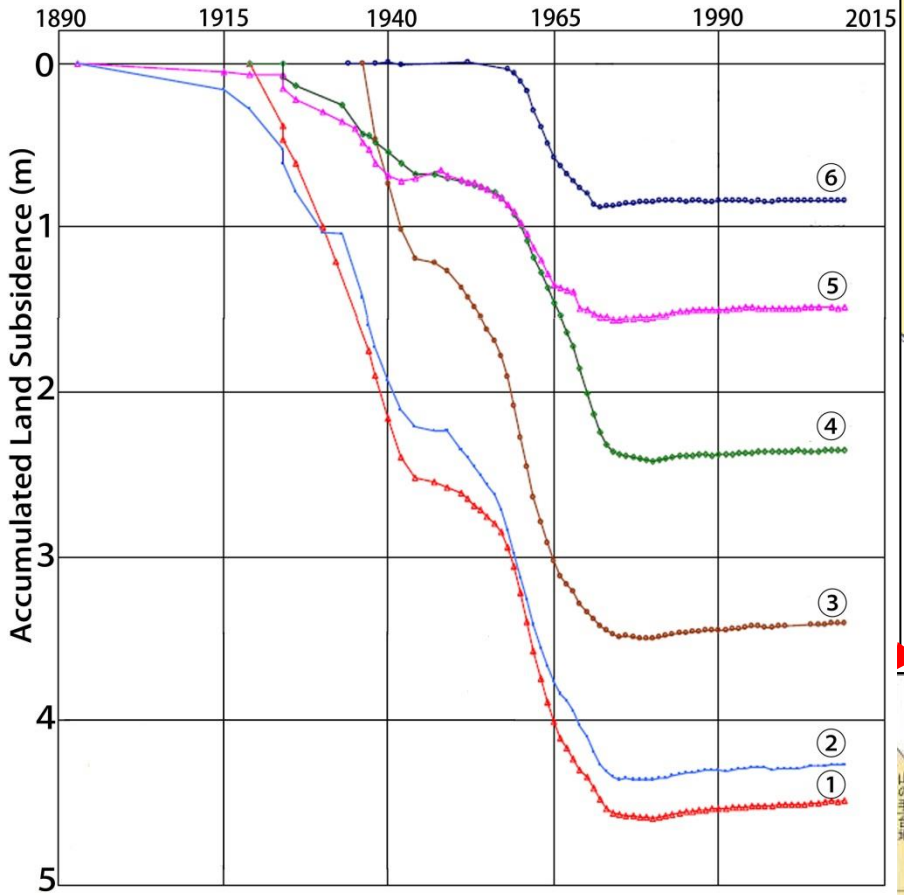
- Example case study: Tokyo (but also Venice)

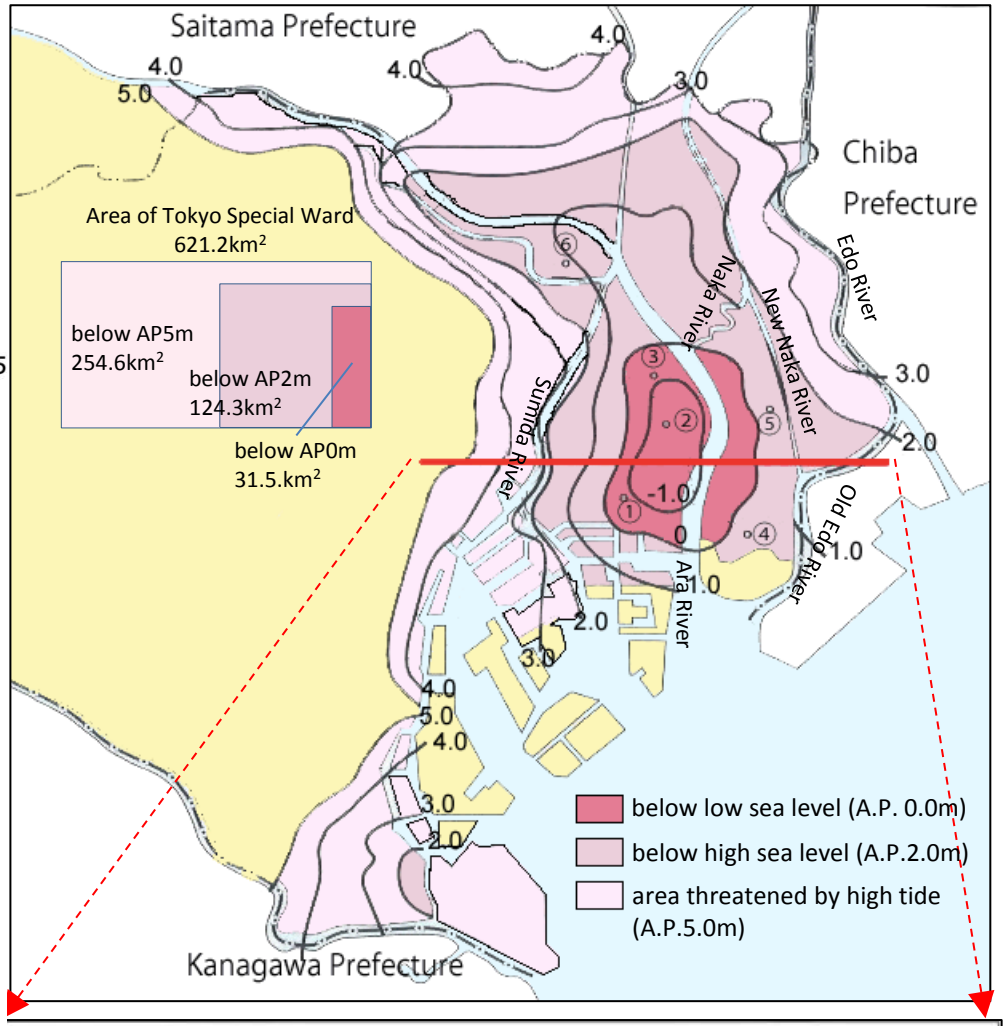
Special thanks to MORIYASU Kunihiro
(Japan International Cooperation Agency)

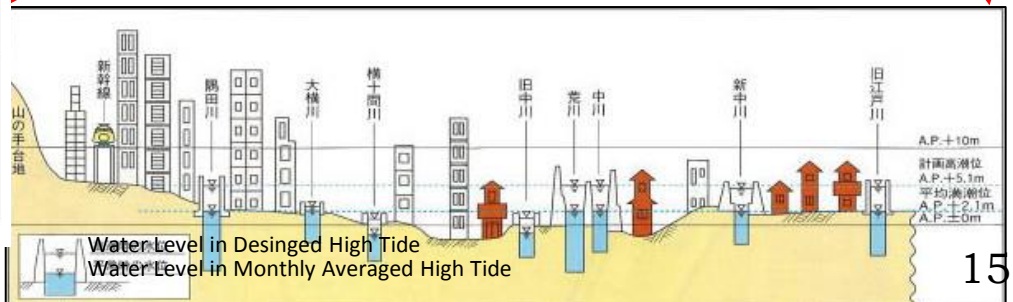


Land Subsidence in Tokyo

- Started in eastern Tokyo in the 1930's.
- In the 1950's subsidence accelerated





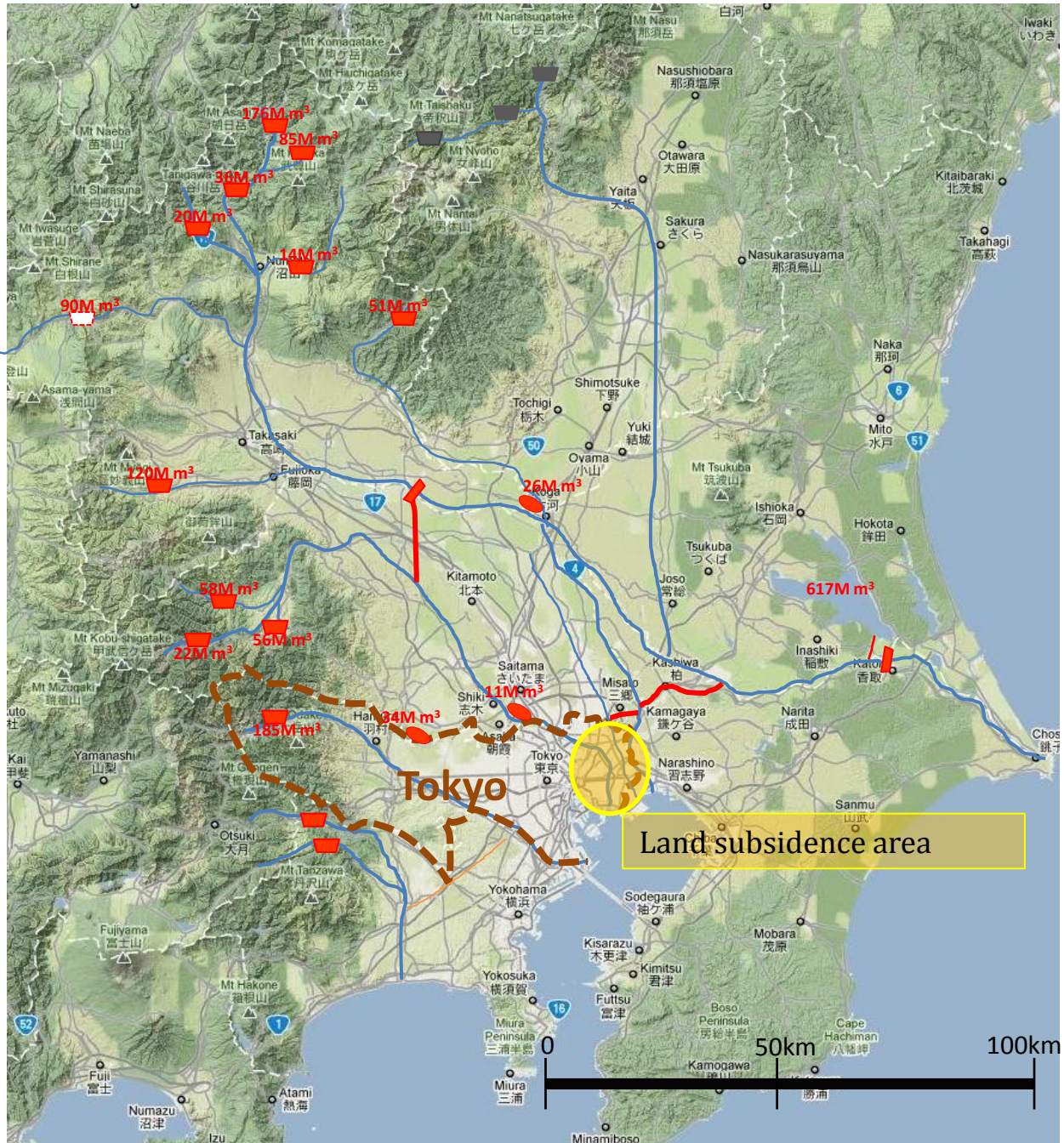


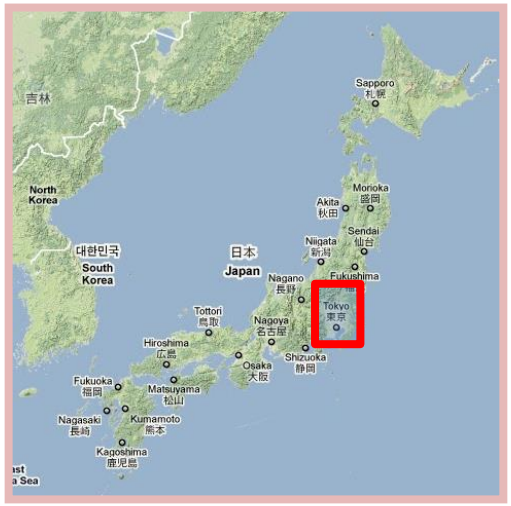
Law and regulations in Tokyo

Laws and regulation	Designated Area	Purpose of Water Use	Structural Criterion		
			Cross Section Area of Discharge Hole		
			-6cm^2	6cm^2-21cm^2	21cm^2-
Industrial Water Law(1956)	8 ward out of 23 (especially land subsidence area)	Manufacture, Supplying Heat, Electricity and Gas	No regulation (out of target of the law)	Strainer must be deeper than 550-650m	Prohibited
Building Water Law(1963)	23 ward (all ward)	Heater and Cooler, Toilet, Washing Cars, Public Bath	No regulation (out of target of the law)	Strainer must be deeper than 400-650m	Prohibited
Regulation of local government for conservation of environment(2001)	All Area	All Purpose	The output capacity of Pump must be less then 2.2kw/ Average Water use must be less than 10m^3/day	Strainer must be deeper than 400-650m	Prohibited

Source: http://www.kankyo.metro.tokyo.jp/water/groundwater/pumping_regulations/outline.html

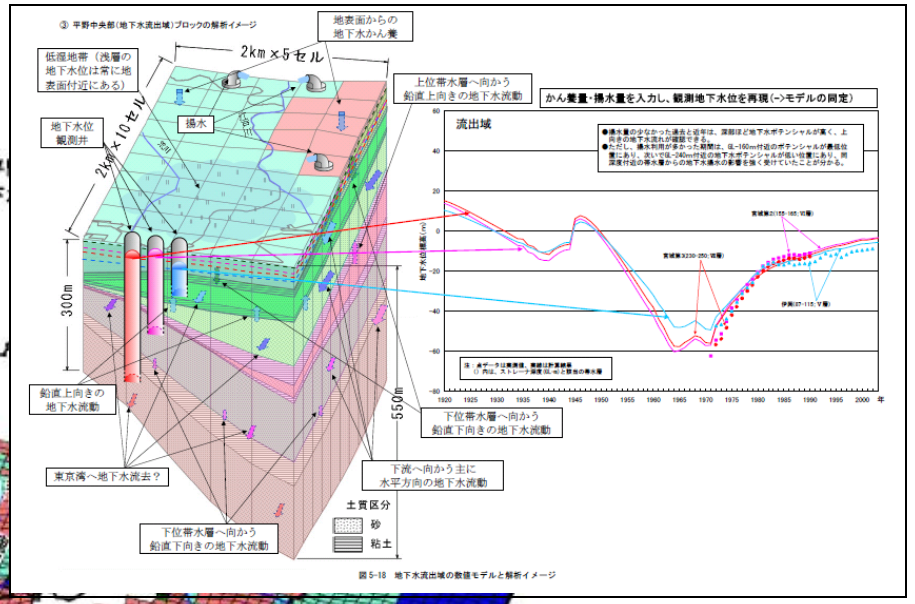
Water supply system for Tokyo from reservoirs

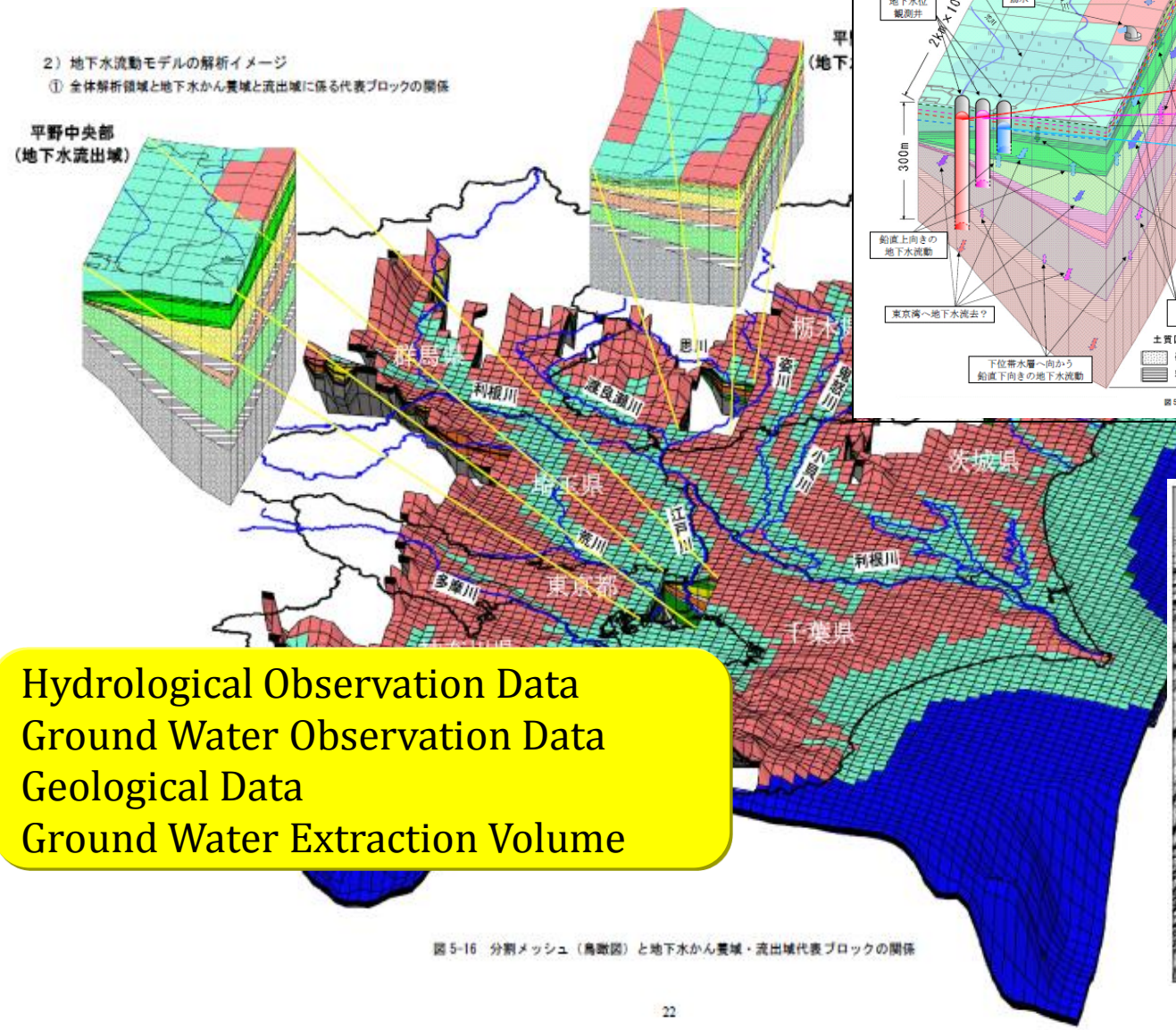


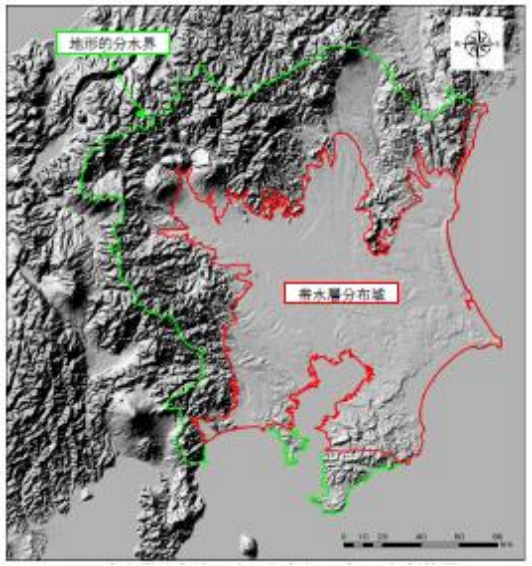


Creating an alternative water source

Groundwater Simulation Model







Hydrological Observation Data
Ground Water Observation Data
Geological Data
Ground Water Extraction Volume

Delayed response to mitigation measures

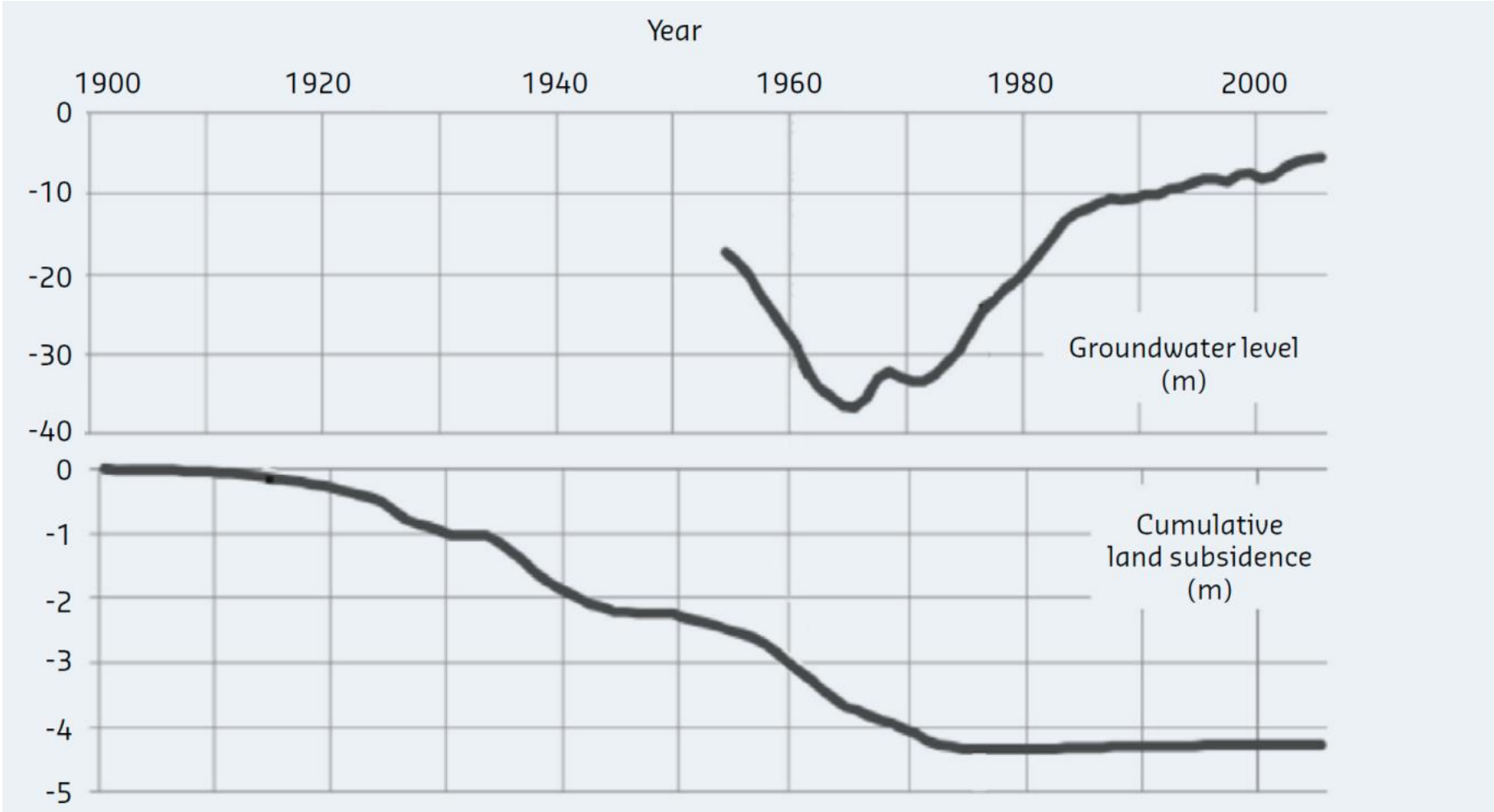


Figure 6. Land subsidence and groundwater level in Tokyo area (Kaneko & Toyota, 2011)

Concluding remarks

- Everyone follows a strategy, as the adaptation strategy is the base-line
- Development a strategy is demanding a large amount of knowledge/data and governance lock-ins may exist
- But…living in soft soil areas is expensive….the costs will always be made:
  - When ignoring the problem (when disaster happens)
  - When following adaptation strategy (continuously levee building)
  - When following mitigation strategy (new water supply system, potentially including waste water treatment)